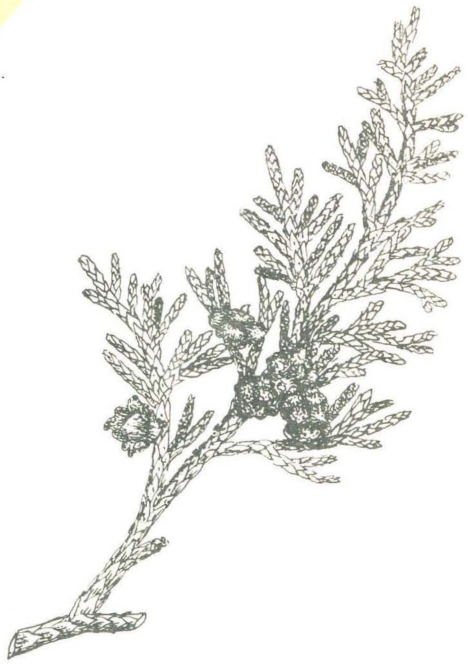
Silvical Characteristics of Atlantic White-Cedar

(*Chamaecyparis thyoides*)

by S. Little



STATION PAPER NO. 118 • NORTHEASTERN FOREST EXPERIMENT STATION • 1959
FOREST SERVICE • U.S. DEPARTMENT OF AGRICULTURE • UPPER DARBY, PA.
RALPH W. MARQUIS, DIRECTOR

Preface

MUCH of the silvical information on our forest trees is widely scattered and sometimes difficult to find. To make this material more readily available, the Forest Service is assembling information on the silvical characteristics of all the important native forest tree species of the United States. It is expected that this information will be published as a comprehensive silvics manual.

This report presents the silvical characteristics of one species. It contains the essential information that will appear in the general manual but has been written with particular reference to the species in the Northeast. Similar reports on other species are being prepared by this Experiment Station, and by several of the other regional forest experiment stations.

Silvical Characteristics of Atlantic White-Cedar

by S. Little

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About the Author ...

SILAS LITTLE *was graduated from Massachusetts State College, and later obtained Master's and Ph.D. degrees in forestry from Yale University. A member of the U.S. Forest Service since 1936, he has worked chiefly on forest-management research in southern New Jersey and eastern Maryland. At present he is in charge of the Coastal Oak-Pine Research Center of the Northeastern Forest Experiment Station, New Lisbon, N.J. Dr. Little is particularly well qualified by his experience to write about Atlantic white-cedar. His Ph.D. thesis dealt with the ecology and silviculture of this species.*

A Highly Prized Species

ATLANTIC white-cedar *(Chamaecyparis thyoides* (L.) B.S.P.*)* has been a highly prized species since Colonial times because of the durability and high quality of its wood. The wood has been used for many purposes: boat boards, shingles and lath, framing, house and boat finish, pails and tanks, cabin logs, posts, and poles. Good white-cedar has always commanded good prices. The highest valuations in the Northeast apparently date to about a century ago, when good stands are reported to have sold for $400 to $1,000 per acre *(2)*. Prices around 1830 in New Jersey ranged from $100 to $300 *(4)*--about the same as today's appraisals of $150 to $300 per acre.

The durability and high value of white-cedar wood led to development of an unusual industry in southern New Jersey during the 19th century--the "mining" of logs. The wood of cedar trees that had long since fallen and been buried under many years' accretions of peat was found to be sound and usable for shingles, fence rails, and various other products *(3)*. However, little of such mining has been done since 1900.

Atlantic white-cedar grows in a narrow coastal belt 50 to 130 miles wide from southern Maine to northern Florida and westward through southern Mississippi *(5, 6)*.[1] The Atlantic white-cedar type, however, has always been a minor one in respect to area occupied. Its distribution within the coastal belt is exceedingly patchy, depending on the occurrence of suitable sites *(8)*. Sections where white-cedar has been of the most commercial importance are southeastern New Jersey, southeastern Virginia, eastern North Carolina, and northwestern Florida.

[1] Although 100 miles has been given as the maximum distance inland (5), Dr. C. F. Korstian of Duke University states in correspondence with the Northeastern Forest Experiment Station that this maximum should be 130 miles.

Habitat Conditions

CLIMATIC

Climate over practically all the range of white-cedar is classed as humid, according to Thornthwaite *(14)*, but varies widely in other respects. Average annual precipitation is between 40 and 64 inches; the length of the frost-free season is 140 to 305 days. On the average, precipitation is well distributed throughout the year. Temperature extremes range from -36° F. in Maine to summer highs of over 100° F. in most sections *(15)*.

EDAPHIC

White-cedar grows on wet ground or in swamps, sometimes on sandy soils, but usually on peat deposits. These peat deposits range in depth from a few inches to as much as 40 feet. They are generally acid, often between 3.5 and 5.5 in pH *(8)*. White-cedar is absent or uncommon in areas where the peat deposits are underlain by clay, or where the peat contains appreciable amounts of silt or clay *(6, 8)*.

PHYSIOGRAPHIC

With its range restricted principally to coastal areas, and to wet or swampy ground, the elevations where white-cedar grows usually are low. Typical elevations in southeastern New Jersey range from about 3 feet, where white-cedars border the tidal marsh, to 140 feet for some inland stands. Occasionally the species is found in upland bogs; it grows in one such bog in northern New Jersey at an elevation of 1,500 feet.

BIOTIC

In southern New Jersey, and probably elsewhere, white-cedar foliage and twigs form a preferred winter browse of white-tailed deer *(Odocoileus virginianus) (10)*. Cottontail rabbits (chiefly *Sylvilagus floridanus)* and, in some areas, meadow mice *(Microtus pennsylvanicus)*, feed on the

Figure 1.--*The natural range of Atlantic white-cedar.*

DISTRIBUTION MAP BY
ELBERT L. LITTLE, JR.
U.S. FOREST SERVICE

seedlings *(8)*. The thickets of white-cedar and associated species also provide excellent cover for deer, rabbits, and some other animals and birds.

Since Atlantic white-cedar occurs characteristically in pure stands (fig. 2), it has been listed in only one cover type *(13)*. However, because of its great latitudinal range many species of trees have been found growing with it. They include red maple *(Acer rubrum)* in all sections; blackgum *(Nyssa sylvatica)*, yellow birch *(Betula alleghaniensis)*, white pine *(Pinus strobus)*, and hemlock *(Tsuga canadensis)* in New England; blackgum, sweetbay *(Magnolia virginiana)*, gray birch *(Betula populifolia)*, and pitch pine *(Pinus rigida)* in southern New Jersey; pond pine *(P. serotina)*, slash pine *(P. elliottii)*, sweetbay, swamp tupelo *(Nyssa sylvatica* var. *biflora)*, baldcypress *(Taxodium distichum)*, redbay *(Persea borbonia)*, loblolly-bay *(Gordonia lasianthus)*, and others in the South *(1, 6, 8)*.

Many nonarborescent plants also grow with white-cedar. In one study involving sixteen 1/10-acre plots in southern New Jersey, 25 shrubs were found associated with it. The most common were sweet pepperbush *(Clethra alnifolia)*, swamp azalea *(Rhododendron viscosum)*, highbush blue-

Figure 2.--*A dense stand chiefly of Atlantic white-cedar. Notice the scarcity of hardwood reproduction and shrubs.*

berry *(Vaccinium corymbosum)*, dangleberry *(Gaylussacia frondosa)*, fetterbush *(Leucothoe racemosa)*, and lowbush blueberry *(V. pallidum) (9)*. In a North Carolina study tetterbush *(Lyonia lucida)* was the most common shrub, but fetterbush, highbush blueberry, and sweet pepperbush also occurred *(1)*.

Few fungi attack white-cedar, and their damage is not usually serious. They include *Keithia chamaecyparissi* and *Lophodermium juniperinum*, which attack white-cedar foliage; *Gymnosporangium ellisii*, which causes a spherical or oblong swelling of a bole or branch and sometimes broom-like devel-

opment of branches; *Gymnosporangium biseptatum*, which causes a spindle-shaped burl; and *Trametes subrosea*, which attacks the heartwood of trees or the sapwood of cut timbers *(6, 8)*.

White-cedar has no serious insect enemies. Larvae of the common bagworm *(Thyridopteryx ephemeraeformis)* may feed on its foliage *(6)*.

Life History

SEEDING HABITS

Flowering and fruiting.--White-cedar flower buds are formed in the summer and, although minute, are discernible in the fall or winter. In New Jersey the brownish staminate buds are only about 1/25 inch long or wide in February; the greenish pistillate buds at the ends of short shoots are about the same size. Pollen shedding usually occurs in early April in southern New Jersey *(7)*.

The cones mature at the end of the first growing season. Full-grown cones are spherical, about 1/4 inch in diameter, and contain 5 to 15 winged seeds *(6)*.

Seed production.--Under favorable conditions, some Atlantic white-cedars only 3 years old bear mature cones. In one study where 1,300 two-year-old seedlings were planted, 2 percent of the trees had mature cones at the end of the first growing season in the field. In one plot of another planting, 20 percent of the 3-year-old seedlings produced one or more cones, and one tree had 64. However, these trees were relatively large--0.9 foot tall. Seedlings that were only 0.35 foot tall produced no cones *(8)*.

Natural reproduction starts bearing seed in open stands at 4 or 5 years, in dense stands at 10 to 20 years *(6)*.

Cone production varies appreciably with tree size and crown class. Intermediate or crowded stems produce markedly fewer cones than open-grown or dominant trees of the same

size. In one comparison of clumped and open-grown trees, the larger, mostly dominant trees in the clumps were fully as productive as open-grown trees of the same size, but the intermediate and smaller clumped trees were much less productive than their open-grown counterparts *(8)*. Average numbers of cones per tree for some selected sizes were:

	In clumps	*Open-grown*
Trees 5 to 7 feet tall	4	52
Trees 3 to 4 inches d.b.h.	1,074	2,891
Trees 5 to 7 inches d.b.h.	4,540	4,218

White-cedar usually produces fair to excellent crops of seed each year. Under one mature stand the catch in seed traps was at the rate of 8 million seeds per acre in one year, 9 million per acre the next year *(8)*.

Observations indicate that little of the seed is consumed by birds or rodents *(6)*.

Seed dissemination.--Natural seed dissemination begins about October 15 in New Jersey, and most of the seed is released before the end of the winter. In one study 39 percent of the crop fell by November 15, more than 60 percent by December 15, and 93 percent by March 1. The rest fell during the remaining months before the next crop started to fall *(8)*.

Seed dispersal is influenced by weather conditions: the cones open when dry and close when wet. However, rather thorough wetting is required to cause open cones to close. In one series of observations, showers of 0.15 inch or less caused only partial closure of some cones, whereas rains of 0.45 inch or more induced full closure of all cones *(8)*.

Wind distributes most of the white-cedar seed, although some may be scattered by floating on water. White-cedar seeds are small, about 460,000 seeds per pound, and their rate of fall is relatively slow--0.6 foot a second in still air. Calculations based upon this rate of fall indicate that, with a 5-mile wind, most of the seed from a 50-foot tree would be carried about 600 feet *(6)*. Hence, one might conclude that most of the seed is widely distributed. However, seed-trap records around and under uncut stands showed that most of the seed falls directly under the stand;

where surrounding vegetation was of comparable height, no seeds were caught beyond 66 feet from the stand's edge.

Where seed distribution from isolated trees was studied, the catch indicated that 60 percent of the seed fell at a distance beyond that equal to the height of the tree--even though the catch per trap decreased greatly with increased distance. Because of weather influences 80 to 85 percent of the seed catch was on the east side of the source *(8)*.

VEGETATIVE REPRODUCTION

White-cedar sometimes develops shoots from lateral branches or from dormant buds on the stem when seedlings or saplings are severely browsed or otherwise injured. One white-cedar seedling girdled by meadow mice produced 26 sprouts 1 to 4 inches long at its base. White-cedar seedlings that have been repeatedly browsed by deer may develop multiple stems through layering (fig. 3). From one such

Figure 3.--*A white-cedar seedling that has layered after repeated browsing by deer. Note the branch on the right that has developed roots.*

seedling, 3 feet tall, fourteen additional stems 0.5 to 3.3 feet tall had developed *(8)*. However, growth of such layered stems is slow.

SEEDLING DEVELOPMENT

Establishment.--The viability of white-cedar seed may vary greatly. Korstian and Brush *(6)* report germination of 70 to 90 percent. But one cutting test of New Jersey seed from a poor crop indicated only 8 percent sound, while actual germination of seed from a good crop the following year reached 76 percent *(8)*.

Viability of seed from trees 3 or 4 years old may be low. At least in two tests only 3 to 25 percent of such seeds germinated *(8)*.

Delayed germination is common in white-cedar seed. Even when seed is sown in the fall in a nursery, half the germination may not occur until the second year. And some of the tremendous amounts of seed produced by mature stands remain viable for an unknown length of time when stored in the forest floor. In one study, spots under mature cedar stands were screened in the fall, before seed had ripened, to exclude new seed. The top layers of forest floor from these spots were collected the next fall; thus these samples had gone through two growing seasons without appreciable additions of new seed, with total exclusion for 1 year. When these samples were placed under conditions favorable for seed germination, the results showed that the surface inch of forest floor had contained 260,000 to 1,100,000 viable seeds per acre, and the underlying 2 inches of peat had contained about the same number--260,000 to 950,000 per acre *(8)*.

The storage of viable seed in the forest floor can be turned to advantage in direct seeding--by using the upper part of the forest floor from mature cedar stands as a source of seed. In one study 780 spots were sown in this manner in early April, using a bushel of the forest floor material for each 20 spots. Two months later 90 to 98 percent of the spots had one or more seedlings (fig. 4), the average number per spot being six *(8)*.

A fair amount of light, probably to provide heat, is desirable for obtaining good germination of white-cedar

seed. However, in one study, light intensity had to be less than 16 percent of full sunlight before germination was greatly reduced, and some germination occurred under hardwoods where the light intensity, measured in August, was only 1 percent of full sunlight *(8)*.

Favorable moisture conditions are highly important for the germination of white-cedar seed and establishment of seedlings. In one experiment involving artificial seeding of white-cedar, 49 percent of the seed germinated in clear-cut plots in a constantly moist swamp, whereas in similar plots on a drier but still poorly drained site, only 16 percent germinated on exposed soil *(8)*. Probably because of the small amount of reserve food in the seed, white-cedar seedlings develop a very short taproot. Hence, the successful establishment of seedlings requires not only adequate surface moisture for seed germination, but also continued moisture within reach of the comparatively shallow roots.

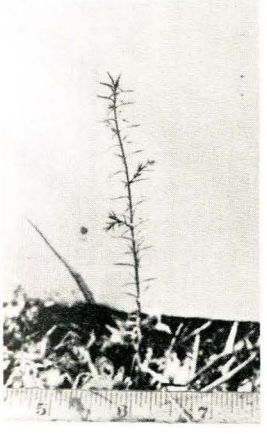

Figure 4.--*A white-cedar seedling produced by direct seeding. This started in a spot on which some of the forest floor from a white-cedar stand had been spread. Photo taken at end of first growing season.*

Suitable seedbeds include rotten wood, peat, sphagnum moss, and moist mineral soil. The first three types of seedbed are common in many swamps. A thick litter of pine needles or the leaves of shrubs and hardwood trees is unfavorable. On one poorly drained site with a thick litter, removing the forest floor from seed spots increased the germination of white-cedar seed from less than 1 percent to 13 percent, and the initial stocking of seeded spots from 3 to 81 percent *(8)*. The old corduroy roads left after logging also are unfavorable seedbeds.

Dense slash is extremely unfavorable for white-cedar establishment. In studies of natural reproduction on cut-over areas, slash-free spots had at least 28 times as many seedlings as the spots covered with dense slash *(6, 8)*.

The microrelief of swamps also greatly affects seedling establishment. In many areas water stands on part of the surface during much of the year, a condition unfavorable to both seed germination and seedling survival. In such swamps suitable conditions are limited to the hummocks above the usual water table. But on the high hummocks seedlings may die during dry periods from insufficient moisture. In general, the younger or smaller the seedlings are, the greater the mortality from either drowning or drought.

Relatively open conditions are needed for good survival and growth of white-cedar seedlings. At light intensities of 4 to 6 percent of full sunlight, as under mature white-cedar stands in New Jersey, seedlings survive for only 1 to 3 years. Partial cuttings, thinning the overstory, enable white-cedar reproduction to live longer, but not so long as competing hardwoods and shrubs. Under a light intensity of 77 percent, the initial growth of white-cedar seedlings was about twice that under a 16-percent intensity, almost 4 times that under a 2-percent intensity. Hence, only relatively open areas, such as abandoned cranberry bogs and clear-cuttings, provide the conditions required by white-cedar seedlings to compete successfully with their hardwood and shrub associates *(8)*.

Early growth.--When growing in swamps under heavy shade, white-cedar seedlings may develop a height of only 1 inch and a taproot depth of only 2 inches during the first year. In contrast, open-grown seedlings may reach an average height of 2.5 inches on unfavorable sites (such as sandy, poorly drained soils or cranberry bogs), and 6 to 10 inches on favorable sites *(6)*.

During the first year, seedlings on relatively dry sites develop longer taproots, but only about half as much total root length as on the wetter, more favorable sites *(8)*.

On favorable open sites seedlings grow 0.6 to 0.9 foot in height during their second year, and somewhat more than a foot a year for a few years thereafter. Under such

conditions, stems 10 feet tall may be 7 or 8 years old in the South, about 10 years old in the Northeast. However, on less favorable sites they may be only 4 to 7 feet tall at 15 years *(6)*.

SAPLING STAGE TO MATURITY

Growth and yield.--On the better sites white-cedar crop trees annually grow 1 to 1½ feet in height and 0.1 to 0.15 inch in diameter (b.h.) until they are 40 to 50 years old. After this age, height growth slows down; it practically ceases at 100 years. Diameter growth, however, continues through the second 50 years at about the same rate as before *(6)*.

In closed stands the lower branches die at an early age but persist for many years. As the dead branches eventually slough off, the trees develop long, clear, straight boles with little taper below the crown; however, little clear lumber is produced during the first 50 years.

Although white-cedar trees are relatively small, the basal area and volume of stands tend to be high because of the great density of stems. On the basis of three ¼-acre plots, one stand in Gates County, North Carolina, had 294 square feet of basal area per acre, 85 percent of which was white-cedar. Yet most of the trees were between 2 and 14 inches (d.b.h.).[2] According to yield tables, basal areas may reach more than 300 square feet per acre *(6)*. Even on a 45-foot site 50-year-old stands may have 245 to 250 square feet of basal area, and total volumes, including stumps and tops, of 4,600 cubic feet *(12)*. At a site index of 40 feet a 60-year-old stand may have 1,700 stems per acre, yielding about 35 cords per acre to a top diameter of 4 inches (i.b.); a 70-year-old stand on a 70-foot site, 350 trees per acre or 110 cords. On a 70-foot site the board-foot yield (to a top diameter i.b. of 6 inches) is 42,900 board-feet, International rule, at 60 years, 71,500 board-feet at 100 years *(6)*

In southern New England (latitude 41° - 42° N.), mature white-cedars reach heights of 40 to 60 feet and di-

[2]Forest survey data obtained by the Southeastern Forest Experiment Station.

ameters of usually less than 16 inches, although some have grown to 4 feet in diameter *(8)*. Optimum development--to a maximum of 120 feet in height and 5 feet in diameter--apparently occurred in the Virginia-North Carolina section at latitudes of 34° to 37° N. *(6)*. The maximum sizes given by Mohr *(11)* for white-cedar in Alabama, at a latitude of about 31° N., are somewhat less: 80 to 90 feet in height, with diameters rarely more than 24 inches.

Potentially white-cedar is a relatively long-lived species: according to one source, some trees have reached 1,000 years in age *(3)*. But, as stands, 200 years may have been the usual maximum *(8)*.

Figure 5.--*An example of gradual windthrow in a white-cedar swamp, favoring the development of understory hardwoods and shrubs. Note the shallow root systems of the white-cedars in this wet peat soil.*

Figure 6.--*A stand of white-cedar that had been thinned 18 years ago. Note the understory of hardwoods and shrubs that has developed. Compare this understory with that of the dense stand in Figure 2.*

Reaction to competition.--White-cedar is more tolerant than such associated species as gray birch and pitch pine, but much less tolerant than red maple, blackgum, sweetbay, and other hardwoods that form the climax on swamp sites in its range *(1, 8)*. White-cedar reproduction can grow through and eventually overtop scattered to moderately dense shrubs such as highbush blueberry, though in the process the cedar shoots may become extremely slender--almost like grass. However, the cedar is not sufficiently tolerant to grow through the denser shrub thickets or through a hardwood overstory.

White-cedar on typical swamp sites is shallow-rooted and subject to windthrow (fig. 5), especially in stands that have been opened by partial cuttings. Thinnings or other partial cuttings also are inadvisable where perpetuation of cedar is desired because the opened stands permit a hardwood understory to become established (fig. 6), making regeneration of cedar after the final cut much more difficult. In view of the hardwood aggression in opened stands, the cedar's susceptibility to windthrow, and its relatively low tolerance, the most practical method of harvest cutting for regenerating the species is clear-cutting of 5- to 10-acre patches or of successive strips.

Cultural measures that commonly will be necessary to establish full stocking of cedar reproduction include slash disposal and control of competing vegetation by cutting or chemicals *(8)*. In some places, deer browsing may so reduce survival and growth that fencing or some other type of protection will be required *(10)*.

In the original forest the white-cedar type must have been perpetuated by extensive disturbances. Although fire is one of the greatest enemies of white-cedar, under certain conditions it also favors perpetuation of this species.

For example, a fire that burns in the crowns and consumes little of the forest floor will kill a white-cedar stand, but the composition of the succeeding stand will vary according to the age of the burned stand and amount of viable seed currently stored in the forest floor, according to proximity to other sources of white-cedar seed, and according to the stocking of hardwoods and shrubs in the understory. Under the right circumstances, the next stand may be chiefly white-cedar; under other circumstances, chiefly hardwood seedlings or sprouts. On the other hand, if a fire burns deep enough to eliminate tree growth of all kinds, one of several conditions or developments may be favored: standing water, or a cover of leatherleaf *(Chamaedaphne calyculata)*, or, if there are hummocks still above the water table, a new stand of white-cedar or other species (the composition depending on available seed supplies).

Other factors that, like fire, may be either destructive or beneficial to white-cedar, depending upon the particular situation, include wild animals, wind, snow, ice, and flooding with fresh or brackish water. While the pres-

ent-day browsing of deer favors competing vegetation, beavers probably favored white-cedar in the original forest through selective cutting of certain hardwoods, flooding of whole areas, and subsequent abandonment of dams when the food was exhausted. Wind, possibly aided by snow or ice, favored hardwood understories at times when white-cedar stands were gradually opened up by the periodic windthrow or breakage of scattered trees (fig. 5); but extensive wind damage in one storm may have favored the development of another white-cedar stand. And along the coast, occasional stands of various species have been killed by salt water brought in by storm tides, sometimes permitting a pure white-cedar stand to follow one composed largely of hardwoods *(8)*.

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These Silvical Papers...

This is one of a series of 15 silvical papers to be published by the Northeastern Forest Experiment Station. The series will include papers on the following species:

Green ash
White ash
Beech
Paper birch
*Sweet birch
Yellow birch
Black cherry
Red maple
Balsam fir
Red spruce
Eastern hemlock
Eastern white pine
Pitch pine
Virginia pine
*Atlantic white-cedar

*Already published.

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